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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 691

Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

Washington, D. C. ▼ July 10, 1918

TYPICAL SPECIFICATIONS FOR BITUMINOUS ROAD MATERIALS

By

PRÉVOST HUBBARD, Chemical Engineer, and
CHARLES S. REEVE, Chemist

CONTENTS

	Page
Introduction	1
Specifications	4
Methods of Testing	47
Samples and Sampling	58

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DETAILED CONTENTS.

	Page.
Introduction	1
Specifications:	
OC-1. Petroleum product for dust palliative	4
OC-2. Road oil for cold application	5
OH-1. Road oil for hot application	7
OA-1. Oil asphalt for construction	9
OA-2. Oil asphalt for construction	11
OA-3. Oil asphalt for construction	13
OA-4. Oil asphalt for construction	15
OA-5. Oil asphalt for construction	17
OA-6. Oil asphalt for construction	19
OA-7. Oil asphalt for construction	21
OAF-1. Oil asphalt for poured joint filler	22
NA-1. Fluxed Bermudez asphalt for construction	23
NA-2. Fluxed Bermudez asphalt for construction	25
NA-3. Fluxed Bermudez asphalt for construction	27
NA-4. Fluxed Bermudez asphalt for construction	29
NA-5. Fluxed Bermudez asphalt for construction	31
NA-6. Fluxed Bermudez asphalt for construction	33
NA-7. Fluxed Bermudez asphalt for construction	34
NA-8. Fluxed Trinidad asphalt for construction	35
NA-9. Fluxed Trinidad asphalt for construction	36
TC-1. Tar for cold application	37
TC-2. Tar for cold application	38
TC-3. Tar for cold patching	39
TH-1. Refined tar for hot application	40
TP-1. Refined tar for construction	41
TP-2. Refined tar for construction	42
TP-3. Refined tar for construction	43
TP-4. Refined tar for construction	44
TP-5. Refined tar for construction	45
TP-6. Refined tar for construction	45
Methods of testing;	
Specific gravity	47
Flash point	48
Specific viscosity	48
Volatilization test	49
Float test	50
Total bitumen	51
Bitumen insoluble in naphtha	53
Melting point	54
Penetration	55
Distilation test	56
Samples and sampling;	
General directions	58
Frequency	58
Information accompanying samples	59
Time and place	59
Size	59
Container	59
Identification	59
Drip samples	59
From storage tanks and tank cars	60
From barrels and drums	60

INDEX ACCORDING TO PURPOSE OF MATERIAL.

	Page.
Dust palliative:	
OC-1. Petroleum product	4
Priming coat:	
TC-1. Tar	37
Cold patching:	
TC-3. Tar	39
Surface treatment—cold:	
OC-2. Road oil	5
TC-2. Tar	38
Surface treatment—hot:	
OH-1. Road oil	7
TH-1. Refined tar	40
Bituminous macadam:	
OA-1. Oil asphalt	9
OA-2. Oil asphalt	11
OA-3. Oil asphalt	13
NA-1. Fluxed Bermudez asphalt	23
NA-2. Fluxed Bermudez asphalt	25
NA-3. Fluxed Bermudez asphalt	27
TP-1. Refined tar	41
TP-2. Refined tar	42
TP-3. Refined tar	43
TP-4. Refined tar	44
TP-5. Refined tar	45
TP-6. Refined tar	46
Bituminous concrete—one-size stone:	
OA-3. Oil asphalt	13
OA-4. Oil asphalt	15
NA-3. Fluxed Bermudez asphalt	27
NA-4. Fluxed Bermudez asphalt	29
TP-3. Refined tar	43
TP-4. Refined tar	44
TP-5. Refined tar	45
TP-6. Refined tar	46
Bituminous concrete—graded coarse aggregate:	
OA-4. Oil asphalt	15
OA-5. Oil asphalt	17
NA-4. Fluxed Bermudez asphalt	29
NA-5. Fluxed Bermudez asphalt	31
Bituminous concrete—graded fine aggregate:	
OA-5. Oil asphalt	17
OA-6. Oil asphalt	19
NA-5. Fluxed Bermudez asphalt	31
NA-6. Fluxed Bermudez asphalt	33
Sheet asphalt;	
OA-6. Oil asphalt	19
OA-7. Oil asphalt	21
NA-6. Fluxed Bermudez asphalt	33
NA-7. Fluxed Bermudez asphalt	34
NA-8. Fluxed Trinidad asphalt	35
NA-9. Fluxed Trinidad asphalt	36
Joint filler:	
OAF-1	22

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CONTENTS.

	Page.		Page.
Introduction	1	Methods of testing	47
Specifications	4	Samples and sampling	58

INTRODUCTION.

Since public attention was first attracted to the use of bituminous materials in road treatment and construction the Office of Public Roads and Rural Engineering has received increasingly numerous requests for specifications which will describe suitable types and grades of such materials for the various uses required in highway engineering. It was early realized that the preparation of standard specifications of any value would be extremely difficult if not impossible, owing to the widely varying characteristics of the materials which should be covered and to the many local factors, such as climate, traffic, and character of available non-bituminous road material, which largely control service results and which should govern the selection of suitable bituminous material. Therefore, attempts were first made to consider every request as an individual problem and to furnish specifications only after certain information relative to local conditions and proposed methods of treatment or construction had been secured.

Gradually, as the result of its own experimental work as well as observation of the work of others, the Office was able to prepare certain specifications which though not considered as standards were found to be in most cases serviceable for general use in well established types of construction and maintenance. Such specifications were called typical specifications and were furnished, upon request, on typewritten or mimeographed sheets. As additional information

was secured, new methods of use devised, and the character of available crude materials and their method of refining changed, these typical specifications were modified from time to time by the Office. Owing to the fact that they are widely distributed among engineers not in close touch with the reasons necessitating their modification, certain of the older specifications are still in use, although not up to date. In so far as possible these engineers have been notified of changes which the Office has seen fit to make, but as, in many cases, the originals have been passed on from one engineer to another all have not been informed of the changes which have been made.

Very recently all of the typical specifications for bituminous materials prepared by the Office have been revised, and it has been considered advisable to publish them in bulletin form for more general distribution. The specifications given in the following pages, therefore, are intended to supersede all prior specifications for bituminous materials issued by the Office. It is felt that these revised specifications have been made as brief and simple as possible without sacrificing to too great an extent three essential purposes, which are (1) to secure a suitable grade of material, (2) to insure reasonable uniformity of supply, and (3) to sufficiently identify the material by type.

No specification should be encumbered with unnecessary requirements, and test limits, of course, should be thoroughly practicable from a manufacturing standpoint. With this in mind the cooperation of all manufacturers of bituminous road materials was sought. In July, 1917, a set of tentative revised specifications was sent to all manufacturers who were thought to be interested, with a request that they review the specifications, suggest changes if they so desired, and state the reasons for such suggested change. In addition the manufacturers were requested to furnish to the office samples of each of their products which conformed to the specifications, together with samples of any products which would meet the specifications if changed in accordance with their suggestions.

Upon receipt of all of the information that could be secured, the comments of the manufacturers were tabulated, together with the test results which they furnished and the analyses of the samples examined in the laboratory of the office. These data were carefully studied and when justified, modifications were made in the tentative specifications which in their revised form are presented in this bulletin. The forms of specification adopted are in general those recommended by the first conference of State Highway Testing Engineers and Chemists.[1]

[1] U. S. Department of Agriculture Bulletin 555.

The specifications appearing in the following pages are grouped according to type of material, as shown in the detailed table of contents. A special index, however, is given for the convenience of engineers interested in materials suitable for particular methods of use or types of construction. Following each specification is a brief paragraph stating the purpose for which the material is intended, its method of use, the type of road, and general conditions for which it is suited, and the results which may be expected if it is properly used.

This information is necessarily general in character and should not be interpreted too rigidly. Varying combinations of climate, traffic, and character of the nonbituminous portion of the road which can not be discussed in a single paragraph will often influence the selection of the bituminous material and its method of use. More detailed information and advice relating to their use in maintenance and construction may be obtained upon application to the office.

It is realized that all classes and types of bituminous materials have not been covered and it is intended to add to the number of these specifications from time to time as additional information is obtained. In the meantime they are offered more as a guide and help to those engineers who are not thoroughly familiar with the characteristics of bituminous materials rather than as a substitute for specifications now in use which have already demonstrated their value in securing the material which is desired. It is realized that the same material is often described by two entirely different sets of tests and test limits, so that the same ultimate result may be obtained by two different specifications. Unfortunately different methods of specifying bituminous materials are followed by various highway engineers and commissions, and it would appear highly desirable that uniform practice in this matter be generally adopted. It is hoped that the typical specifications here given may further such practice, in the interests of both consumer and producer.

For the convenience of engineers and in order to make this bulletin complete in itself the methods of test to which reference is made in the specifications, and directions for sampling are included in this bulletin.

SPECIFICATIONS.

OC–1. PETROLEUM PRODUCT FOR DUST PALLIATIVE.

General. The petroleum product shall be homogeneous and free from water.

Physical and chemical properties. It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_not more than 0.940
2. Flash point_____not less than 100° C. (212° F.)
3. Specific viscosity at 25° C. (77° F.)_____not more than 10
4. Loss at 163° C. (325° F.), 5 hours_____not more than 15%
   a. Float test of residue at 32° C. (89.6° F.)_____liquid
5. Total bitumen (soluble in carbon disulphide), not less than 99.8%

Methods of testing. Tests of the physical and chemical properties of the petroleum product shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 4.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Specific viscosity (on first 50 c. c.), U. S. Department of Agriculture Bulletin 314, p. 7.
4. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19.
   a. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
5. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides primarily for a material to be used as a dust palliative on macadam, shell, gravel, or well compacted earth or sand-clay roads. It is not expected to build up a bituminous mat on the road surface, as materials meeting this specification are deficient in binding value. The specification is intended to cover some crude petroleums, heavy petroleum distillates, and light fluid residual petroleums.

To obtain the best results the road surface should be free of any great excess of dust when the application is made. The oil may be applied without heating and the application should preferably be made by means of a pressure distributor at the rate of from one-eighth to one-fourth of a gallon per square yard. No cover of earth, sand, gravel, or stone chips should be necessary. The number of applications required to lay the dust successfully throughout an entire season will depend upon traffic and climatic conditions; one may prove sufficient, but three or four may be required.

OC–2. ROAD OIL FOR COLD APPLICATION.

General.

The road oil shall be homogeneous and free from water. It shall meet the following requirements:

Physical and chemical properties.

1. Specific gravity 25°/25°C. (77°/77°F.)____ 0.935 to 0.970
2. Fash point_____not more than 50°C. (122°F.)
3. Specific viscosity at 25°C. (77°F.)_____80 to 120
4. Loss at 163°C. (325°F.), 5 hours_____not more than 30%
   a. Float test of residue at 50° C. (122° F.), not less than 90 sec.
5. Total bitumen (soluble in carbon disulphide), not less than 99.5%
6. Per cent of total bitumen insoluble in 86°B. naphtha, not less than 6.0%

Methods of testing.

Tests of the physical and chemical properties of the road oil shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 4.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Specific viscosity (on first 50 c.c.), U. S. Department of Agriculture Bulletin 314, p. 7.
4. Volatilization test (loss at 163°C.), U. S. Department of Agriculture Bulletin 314, p. 19.
   a. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
5. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.
6. Bitumen insoluble in naphtha, U. S. Department of Agriculture Bulletin 314, p. 28.

This specification provides primarily for a material to be used in the cold surface treatment of macadam or shell roads to form a thin wearing mat or carpet which may be maintained or built up by subsequent treatments of either the same type of material or a heavier product (specification OH–1). The specification is intended to cover certain types of crude or topped petroleums and cut-back oil asphalts.

A successful treatment requires that the road surface shall be in a good state of repair, well consolidated, free from holes or depressions, and thoroughly swept for the removal of dust and detritus before the application is made. Newly constructed roads should be permitted to consolidate under traffic before the oil is applied. The oil may be applied without heating, and the initial applications should be made by means of a pressure distributer at the rate of from one-third to one-half a gallon per square yard. It should be covered with a uniform layer of dustless broken stone, all of which will pass a one-half or three-

fourths-inch laboratory screen, or with pea gravel, which will pass a one-half-inch laboratory screen in an amount just sufficient to absorb the bitumen and to prevent the surface from picking up under traffic. Subsequent applications may be made by a pressure distributer or by brooming the oil uniformly over the road surface. From one-tenth to one-fifth gallon per square yard will usually prove sufficient, and this should be covered with coarse sand or stone clips which will pass a one-inch laboratory screen.

To secure best results the treatment should be applied in the early summer, excepting in localities where snow and freezing weather are not common. Under favorable conditions a treatment should last throughout at least one season.

OH-1. ROAD OIL FOR HOT APPLICATION.

General.

The road oil shall be homogenous, free from water, and shall not foam when heated to 120° C. (248° F.)

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), not less than 0.980
2. Flash point_____not less than 80° C. (176° F.)
3. Specific viscosity 100° C. (212° F.)_____not more than 60
4. Float test at 32° C. (89.6° F.)_____not less than 60 sec.
5. Loss at 163° C. (325° F.), 5 hours_____not more than 15%
   a. Float test of residue 50° C. (122° F.), not less than 110 sec.
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
7. Per cent of total bitumen insoluble in 86° B. naptha, not less than 6.0%

Methods of testing.

Tests of the physical and chemical properties of the road oil shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Specific viscosity (on first 50 c. c), U. S. Department of Agriculture Bulletin 314, p. 7.
4. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.
7. Bitumen insoluble in naphtha, U. S. Department of Agriculture Bulletin 314, p. 28.

This specification provides primarily for a material to be used in the hot surface treatment of macadam, gravel, or shell roads, to form a wearing mat or carpet. The specification is intended to cover residual asphaltic petroleums, cut-back oil asphalts, and some crude asphaltic petroleums.

A successful treatment requires that the road surface shall be in a good state of repair, well consolidated, free from holes or depressions, and thoroughly swept for the removal of dust and detritus before the application is made. Newly constructed or resurfaced roads should be permitted to consolidate under traffic before the oil is applied. The oil should be heated to a temperature of 200° F to 250° F. before applying, and the application should be made by means of a pressure distributor at the rate of

from one-third to one-half gallon per square yard. It should be covered with a uniform layer of dustless broken stone all of which will pass a one-inch or three-fourths inch laboratory screen or pea gravel which will pass a one-half inch laboratory screen in an amount just sufficient to absorb the bitumen and to prevent the surface from picking up under traffic. Subsequent applications may be made by a pressure distributor or by brooming the oil uniformly over the road surface. From one-tenth to one-fifth gallon per square yard will usually prove sufficient, and this should be covered with coarse sand or stone chips which will pass a one-half inch laboratory screen. To obtain best results the treatment should be applied in the early summer except in localities where snow and freezing weather are not common. Under favorable conditions with occasional patching of any breaks in the surface a treatment should last for several years.

OA-1. OIL ASPHALT FOR CONSTRUCTION.

General.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)—not less than 1.000
2. Flash point—not less than 175° C. (347° F.)
3. Melting point—35° C. (95° F.) to 55° C. (131° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec.—120 to 150
5. Loss at 163° C. (325° F.) 5 hours—not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec.—not less than 70
6. Total bitumen (soluble in carbon disulphide)—not less than 99.5%
   a. Organic matter insoluble—not more than 0.2%

NOTE.—Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T, Proceedings A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the northern United States. It is intended to cover satisfactory grades of oil asphalts prepared from Mexican, California, Texas, and other petroleums.

It should be applied at a temperature of from 275° F. to 350° F. to the upper or wearing course of compacted broken stone at the rate of from $1\frac{1}{2}$ to $1\frac{3}{4}$ gallons per square yard. The application may be made by means of pouring pots or by a pressure distributor so designed that it will not produce ruts during application. The above quantities are based on a wearing course 3 inches in thickness before rolling, composed of a product which will pass a 2 to 3-inch laboratory screen and be retained on a 1-inch laboratory screen. The exact range in size should be governed by the kind and quality of rock used. The application should be followed by a sufficient amount of clean small sized broken

stone to fill the surface voids when thoroughly rolled. A seal coat of the hot asphalt should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with oil surface treatments using the materials and methods given under specifications OC–2 or OH–1. The latter is usually to be preferred. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

OA–2. OIL ASPHALT FOR CONSTRUCTION.

General.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.)

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)—not less than 1.000
2. Flash point—not less than 175° C. (347° F.)
3. Melting point—35° C. (95° F.) to 55° C. (131° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec—90 to 120
5. Loss at 163° C. (325° F.) 5 hours—not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec—not less than 60
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
   a. Organic matter insoluble—not less than 0.2%

NOTE.—Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proceedings A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the middle belt of the United States. It is intended to cover satisfactory grades of oil asphalts prepared from Mexican, California, Texas, and other petroleums.

It should be applied at a temperature of from 300° F. to 350° F. to the upper or wearing course of compacted broken stone at the rate of from $1\frac{1}{2}$ to $1\frac{3}{4}$ gallons per square yard. The application may be made by means of pouring pots or by a pressure distributor so designed that it will not produce ruts during application. The above quantities are based on a wearing course 3 inches in thickness before rolling, composed of a product which will pass a 2 to 3 inch laboratory screen and be retained on a 1-inch laboratory screen. The exact range in size should be governed

by the kind and quality of rock used. The application should be followed by a sufficient amount of clean small-sized broken stone to fill the surface voids when thoroughly rolled. A seal coat of the hot asphalt should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with oil surface treatments, using the materials and methods given under specifications OC–2 or OH–1. The latter is usually to be preferred. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

OA–3. OIL ASPHALT FOR CONSTRUCTION.

General.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)—not less than 1.010
2. Flash point—not less than 175° C. (347° F.)
3. Melting point—40° C. (104° F.) to 60° C. (140° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec—80 to 90
5. Loss at 163° C. (325° F.) 5 hours—not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec—not less than 50
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
   a. Organic matter insoluble—not more than 0.2%

NOTE.—Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D–36–16 T. Proceedings A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the southern United States or for one size stone bituminous concrete in the northern United States. It is intended to cover satisfactory grades of oil asphalts prepared from Mexican, California, Texas, and other petroleums.

In bituminous macadam construction it should be applied in the manner outlined under Specification OA–2.

One size stone bituminous concrete contemplates a mixture of the asphalt with a crusher product passing a 1¾-inch screen and retained upon a half-inch screen. The asphalt should be heated to a temperature of from 275° F. to 325° F. and the crushed stone to a temperature of from 150° F. to 250° F. before mixing. The mixture should contain from 5 per cent to 7 per cent bitumen. The hot mixture should be deposited in a uniform layer over a

concrete or well-compacted broken stone or gravel foundation to such depth that it will yield a uniform layer two inches in thickness after thorough rolling. A seal coat of the hot asphalt should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with oil-surface treatments using the materials and methods given under specifications OC–2 or OH–1. The latter is usually to be preferred. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

OA–4. OIL ASPHALT FOR CONSTRUCTION.

General.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), not less than 1.010
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____40° C. (104° F.) to 60° C. (140° F.)
4. Penetration at 25° C. (77° F.) 100 g., 5 sec_____70 to 80
5. Loss at 163° C. (325° F.) 5 hours_____not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 45
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
   a. Organic matter insoluble_____not more than 0.2%

NOTE.—Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T, Proceedings A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of one size stone bituminous concrete in the southern United States or of graded coarse aggregate bituminous concrete in the northern United States. It is intended to cover satisfactory grades of oil asphalts prepared from Mexican, California, Texas, and other petroleums.

In one size stone bituminous concrete construction it should be used in the manner outlined under Specification OA–3.

Graded coarse aggregate bituminous concrete contemplates a mixture of the oil asphalt with crushed stone or a mixture of crushed stone and sand well graded in size from particles approximately one-half the thickness of the wearing course to dust. The asphalt should be heated to a temperature of from 275° F., to

325° F., and the mineral aggregate to a temperature of from 250° F., to 300° F., before mixing. The mixture should contain from 6% to 8% bitumen, and will vary within these limits with the character of the rock and the exact grading of the aggregate. The hot mixture should be deposited in a uniform layer over a concrete or well compacted broken stone or gravel foundation to such depth that it will yield a uniform layer 2 to 2½ inches in thickness after thorough rolling. A seal coat of the hot oil asphalt should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with oil surface treatments using the materials and methods given under Specifications OC–2 or OH–1. The latter is usually to be preferred. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

OA–5. OIL ASPHALT FOR CONSTRUCTION.

General.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_not less than 1.010
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____40° C. (104° F.) to 60° C. (140° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____60 to 70
5. Loss at 163° C. (325° F.), 5 hours_____not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.) 100 g., 5 sec_____not less than 40
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
   a. Organic matter insoluble_____not more than 0.2%

NOTE.—Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T, Proceedings A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of graded coarse aggregate bituminous concrete in the southern United States or for graded fine aggregate bituminous concrete in the northern United States. It is intended to cover satisfactory grades of oil asphalts prepared from Mexican, California, Texas, and other petroleums.

In graded coarse aggregate bituminous concrete construction it should be used in the manner outlined under Specification OA–4.

Graded fine aggregate bituminous concrete contemplates a mixture of the oil asphalt with crushed stone or a mixture of crushed stone and sand well graded in size from particles that will pass a one-half-inch laboratory screen to dust such as the "Topeka" type of pavement with its modifications. The asphalt should be heated

to a temperature of from 275° F. to 325° F. and the mineral aggregate to a temperature of from 250° F. to 300° F. before mixing. The mixture should contain from 7 per cent to 11 per cent bitumen and will vary within these limits with the character of the rock and the exact grading of the aggregate. The hot mixture should be deposited in a uniform layer over a concrete or well compacted broken stone or gravel foundation to such depth that it will yield a uniform layer 2 inches in thickness after thorough rolling. A seal coat should not be necessary on this type of pavement, which is usually maintained by patching with the same mixture used in construction.

OA–6. OIL ASPHALT FOR CONSTRUCTION.

General.

The oil asphalt shall be homogeneous, free from water and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), not less than 1.020
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____40° C. (104° F.) to 60° C. (140° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____50 to 60
5. Loss at 163° C. (325° F.) 5 hours_____not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.) 100 g., 5 sec_____not less than 30
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
   a. Organic matter insoluble_____not more than 0.2%

NOTE.—Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Argiculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16–T, Proceedings A. S. T. M., 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of graded fine aggregate bituminous concrete in the southern United States or for sheet asphalt construction in the northern United States. It may also be used as a seal coat on tar macadam or tar concrete roads. It is intended to cover satisfactory grades of oil asphalt prepared from Mexican, California, Texas, and other petroleums.

In fine aggregate bituminous concrete construction it should be used in the manner outlined under specification OA–5.

Sheet asphalt construction contemplates a mixture of the oil asphalt with properly graded sand and a mineral filler. The asphalt and sand should be heated separately to a temperature of from 275° F. to 325° F. The filler should be added to the

hot sand and followed by the asphalt. The mixture should contain from 9 per cent to 12 per cent bitumen and will vary within these limits with the exact grading of the aggregate. After thorough mixing the hot mixture should be deposited in a uniform layer on a binder course which has been previously laid over a concrete base. It should be laid to such depth that it will yield a uniform layer 1½ or 2 inches in thickness as may be required after thorough rolling.

As a seal coat for tar macadam or tar concrete roads it is applied during construction of the road at a temperature of from 300° F. to 350° F. It is used as a substitute for tar seal coat and may be applied at the same rate and covered in the same manner as described under Specifications TP–2 and TP–3.

OA-7. OIL ASPHALT FOR CONSTRUCTION.

General.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)__not less than 1.020
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____45° C. (113° F.) to 65° C. (149° F.
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____40 to 50
5. Loss at 163° C. (325° F.) 5 hours____not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 25
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
   a. Organic matter insoluble_____not more than 0.2%

NOTE.—Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T, Proceedings A. S. T. M., 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used for sheet asphalt construction in the southern United States or for the same type of construction in the northern United States to withstand very heavy traffic. It is intended to cover satisfactory grades of oil asphalts prepared from Mexican, California, Texas, and other petroleums.

Sheet asphalt construction contemplates a mixture of the oil asphalt with properly graded sand and a mineral filler. The asphalt and sand should be heated separately to a temperature of from 275° F. to 325° F. The filler should be added to the hot sand and followed by the asphalt. The mixture should contain from 9 per cent to 12 per cent bitumen and will vary within these limits with the exact grading of the aggregate. After thorough mixing the hot mixture should be deposited in a uniform layer on a binder course which has been previously laid over a concrete base. It should be laid to such depth that it will yield a uniform layer 1½ or 2 inches in thickness as may be required after thorough rolling.

OAF–1. OIL ASPHALT FOR POURED-JOINT FILLER.

General.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 200° C. (392° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.), not less than 0.980
2. Flash point_____not less than 200° C. (392° F.)
3. Melting point_____not less than 80° C. (172° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____30 to 50
   Penetration at 0° C. (32° F.), 200 g., 1 min., not less than 20
   Penetration at 46.1° C. (115° F.), 50 g., 1 sec., not more than 100
5. Loss at 163° C. (325° F.), 5 hours____not more than 1.0%
   Penetration of residue at 25° C. (77° F.), 100 g., 5 sec., not less than 20
6. Total bitumen (soluble in carbon disulphide), not less than 99.5%
   a. Organic matter insoluble_____not more than 0.2%

Methods of testing.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T, Proceedings A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for an oil asphalt filler to be used in filling the joints of brick or stone block pavements. It may also be used to fill expansion joints.

All of the longitudinal and transverse joints between the brick should, when clean and dry, be completely filled with the bituminous filler heated to a temperature of not less than 350° F., nor more than 400° F., as directed. The filler should preferably be applied by means of pouring cans provided with a conical outlet and means for the control of the flow of filler. A top dressing of clean dry sand should be spread immediately after the filler is applied.

NA-1. FLUXED BERMUDEZ ASPHALT FOR CONSTRUCTION.

General.

The fluxed native asphalt shall be homogenous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.025 to 1.050
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____35° C. (95° F.) to 45° C. (113° F.)
4. Penetration at 25° C. (77° F.) 100 g., 5 sec_____120 to 150
5. Loss at 163° C. (325° F.), 5 hours_____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec. not less than 60
6. Total bitumen (soluble in carbon disulphide), not less than 95.0%
   b. Inorganic matter insoluble_____1.5% to 2.5%

Methods of testing.

Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Penetration. A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the northern United States. It is intended to cover satisfactory grades of products prepared by fluxing Bermudez asphalt.

It should be applied at a temperature of from 275° F., to 350° F., to the upper or wearing course of compacted broken stone at the rate of from 1½ to 1¾ gallons per square yard. The application may be made by means of pouring pots or by a pressure distributor so designed that it will not produce ruts during application. The above quantities are based on a wearing course 3 inches in thickness before rolling, composed of a product which will at least pass a 3-inch laboratory screen and be retained on a 1-inch laboratory screen. The exact range in size should be governed by the kind and quality of rock used. The application should be followed by a sufficient amount of clean small sized

broken stone to fill the surface voids when thoroughly rolled. A seal coat of the same bituminous material should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with oil surface treatments using the materials and methods given under Specification OC–2 or OH–1. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

NA–2. FLUXED BERMUDEZ ASPHALT FOR CONSTRUCTION.

General.

The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.)

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.030 to 1.050
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____40° C. (104° F.) to 50° C. (122° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____90 to 120
5. Loss at 163° C. (325° F.), 5 hours____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 45
6. Total bitumen (soluble in carbon disulphide), not less than 95.0%
   b. Inorganic matter insoluble_____1.5% to 2.5%

Methods of testing.

Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the middle belt of the United States. It is intended to cover satisfactory grades of products prepared by fluxing Bermudez asphalt.

It should be applied at a temperature of from 300° F. to 350° F., to the upper or wearing course of compacted broken stone at the rate of from 1½ to 1¾ gallons per square yard. The application may be made by means of pouring pots or by a pressure distributor so designed that it will not produce ruts during application. The above quantities are based on a wearing course 3 inches in thickness before rolling, composed of a product which will at least pass a 3-inch laboratory screen and be retained on a 1-inch laboratory screen. The exact range in size should be governed by the kind and quality of rock used. The application

should be followed by a sufficient amount of clean small sized broken stone to fill the surface voids when thoroughly rolled. A seal coat of the same bituminous material should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with oil surface treatments using the materials and the methods given under specifications OC–2 or OH–1. The latter is usually to be preferred. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

NA–3. FLUXED BERMUDEZ ASPHALT FOR CONSTRUCTION.

General.

The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity, 25°/25° C. (77°/77° F.)_____1.050 to 1.070
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____40° C. (104° F.) to 50° C. (122° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____80 to 90
5. Loss at 163° C. (325° F.), 5 hours_____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 40
6. Total bitumen (soluble in carbon disulphide), not less than 95.0%
   b. Inorganic matter insoluble_____1.5% to 3.0%

Methods of testing.

Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the southern United States, or for one size stone bituminous concrete in the northern United States. It is intended to cover satisfactory grades of products prepared by fluxing Bermudez asphalt.

In bituminous macadam construction it should be applied in the manner outlined under Specification NA–2.

One size stone bituminous concrete contemplates a mixture of the fluxed asphalt with a crusher product passing a 1¼-inch screen and retained upon a one-half inch screen. The bituminous material should be heated to a temperature of from 275° F. to 325° F., and the crushed stone to a temperature of from 150° F. to 250° F., before mixing. The mixture should contain from 5% to 7% bitumen and will vary within these limits with the exact grading of the aggregate. The hot mixture should be deposited in a uni-

form layer over a concrete or well compacted broken stone or gravel foundation to such depth that it will yield a uniform layer 2 inches in thickness after thorough rolling. A seal coat of the same bituminous material should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with oil surface treatments using the materials and methods given under Specifications OC–2 or OH–1. The latter is usually to be preferred. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

NA–4. FLUXED BERMUDEZ ASPHALT FOR CONSTRUCTION.

General. The fluxed native asphalt shall be homogenous, free from water, and shall not foam when heated to 175° C. (347° F.)

Physical and chemical properties. It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.050 to 1.070
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____40° C (104° F) to 50° C. (122° F.)
4. Penetration at 25° C. (77° F.), 100 g. 5 sec_____70 to 80
5. Loss at 163° C. (325° F.), 5 hours_____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 35
6. Total bitumen (soluble in carbon disulphide), not less than 95.0%
   b. Inorganic matter insoluble_____2.0% to 3.5%

Methods of testing. Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cut), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D36 16T., Proc. A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of one size stone bituminous concrete in the southern United States or of graded coarse aggregate bituminous concrete in the northern United States. It is intended to cover satisfactory grades of products prepared by fluxing Bermudex asphalt.

In one size stone bituminous concrete construction it should be used in the manner outlined under Specification NA–3.

Graded coarse aggregate bituminous concrete contemplates a mixture of the fluxed asphalt with crushed stone or a mixture of crushed stone and sand, well graded in size, from particles approximately one-half the thickness of the wearing course to dust. The bituminous material should be heated to a temperature of from 275° F. to 325° F., and the mineral aggregate to a temperature of from 250° F. to 300° F. before mixing. The mixture should contain from 6 per cent to 8 per cent bitumen and will vary within these limits with the character of the rock and the

exact grading of the aggregate. The hot mixture should be deposited in a uniform layer over a concrete or well compacted broken stone or gravel foundation to such depth that it will yield a uniform layer 2 inches in thickness after thorough rolling. A seal coat of the same bituminous material should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of chips to just absorb the excess bitumen. Roads of this character may be maintained with oil surface treatments, using the materials and methods given under Specifications OC–2 or OH–1. The latter is usually to be preferred. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

NA–5. FLUXED BERMUDEZ ASPHALT FOR CONSTRUCTION.

General.

The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)____1.050 to 1.070
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____45° C. (113° F.) to 55° C. (131° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____60 to 70
5. Loss at 163° C. (325° F.), 5 hours____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 30
6. Total bitumen (soluble in carbon disulphide), not less than 94.5%.
   b. Inorganic matter insoluble_____2.0% to 3.5%

Methods of testing.

Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D–36–16 T., Proc. A. S. T. M., 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of graded coarse aggregate bituminous concrete in the southern United States or of graded fine aggregate bituminous concrete in the northern United States. It is intended to cover satisfactory grades of products prepared by fluxing Bermudez asphalt.

In graded coarse aggregate bituminous concrete construction it should be used in the manner outlined under Specification NA–4.

Graded fine aggregate bituminous concrete contemplates a mixture of the fluxed asphalt with crushed stone or a mixture of crushed stone and sand well graded in size from particles that will pass a one-half-inch laboratory screen to dust such as the "Topeka" type of pavement with its modifications. The bituminous material should be heated to a temperature of from 275° F. to 325° F. and the mineral aggregate to a temperature of from

250° F. to 300° F. before mixing. The mixture should contain from 7 per cent to 11 per cent bitumen and will vary within these limits with the character of the rock and the exact grading of the aggregate. The hot mixture should be deposited in a uniform layer over a concrete or a well-compacted broken stone or gravel foundation to such depth that it will yield a uniform layer two inches in thickness after thorough rolling. A seal coat should not be necessary on this type of pavement, which is usually maintained by patching with the same mixture used in construction.

NA–6. FLUXED BERMUDEZ ASPHALT FOR CONSTRUCTION.

General.

The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.050 to 1.070
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____ 45° C. (113° F.) to 55° C. (131° F.)
4. Penetration at 25° C. (77° F.)., 100 g., 5 sec_____50 to 60
5. Loss at 163° C. (325° F.), 5 hours____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 25
6. Total bitumen (soluble in carbon disulphide), not less than 94.0%.
   b. Inorganic matter insoluble _____2.5% to 4.0%

Methods of testing.

Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of graded fine aggregate bituminous concrete in the southern United States or for sheet asphalt construction in the northern United States. It is intended to cover satisfactory grades of products prepared by fluxing Bermudez asphalt.

In fine aggregate bituminous concrete construction it should be used in the manner outlined under Specification NA–5.

Sheet asphalt construction contemplates a mixture of the fluxed asphalt with properly graded sand and a mineral filler. The bituminous material and sand should be heated separately to a temperature of from 275° F. to 325° F. The filler should be added to the hot sand and followed by the asphalt. The mixture should contain from 9 to 12 per cent bitumen and will vary within these limits with the exact grading of the aggregate. After thorough mixing the hot mixture should be deposited in a uniform layer on a binder course which has been previously laid over a concrete base. It should be laid to such depth that it will yield a uniform layer 1½ or 2 inches in thickness as may be required after thorough rolling.

NA-7. FLUXED BERMUDEZ ASPHALT FOR CONSTRUCTION.

General. The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties. It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)____1.055 to 1.075
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____45° C. (113° F.) to 55° C. (131° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____40 to 50
5. Loss at 163° C. (325° F.), 5 hours_____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 20
6. Total bitumen (soluble in carbon disulphide), not less than 94.0%
   b. Inorganic matter insoluble_____2.5% to 4.0%

Methods of testing. Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50 gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used for sheet asphalt construction in the southern United States or for the same type of construction in the northern United States to withstand very heavy traffic. It is intended to cover satisfactory grades of products prepared by fluxing Bermudez asphalt.

Sheet asphalt construction contemplates a mixture of the fluxed asphalt with properly graded sand and a mineral filler. The asphalt and sand should be heated separately to a temperature of from 275° F. to 325° F. The filler should be added to the hot sand and followed by the asphalt. The mixture should contain from 9 per cent to 12 per cent bitumen and will vary within these limits with the exact grading of the aggregate. After thorough mixing the hot mixture should be deposited in a uniform layer on a binder course which has been previously laid over a concrete base. It should be laid to such depth that it will yield a uniform layer 1½ or 2 inches in thickness as may be required after thorough rolling.

NA–8. FLUXED TRINIDAD ASPHALT FOR CONSTRUCTION.

General.

The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175°C. (347°F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.200 to 1.250
2. Flash point_____not less than 175°C. (347°F.)
3. Melting point_____45°C. (113°F.) to 55°C. (131°F.)
4. Penetration at 25°C. (77°F.), 100 g., 5 sec_____50 to 60
5. Loss at 163°C. (325°F.), 5 hours_____not more than 3.0%
   a. Penetration of residue at 25°C. (77°F.), 100 g., 5 sec_____not less than 25
6. Total bitumen (soluble in carbon disulphide), not less than 68.0%
   b. Inorganic matter insoluble_____20.0% to 30.0%

Methods of testing.

Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin, 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used for sheet asphalt construction in the northern United States. It is intended to cover satisfactory grades of products prepared by fluxing Trinidad asphalt.

Sheet asphalt construction contemplates a mixture of the fluxed asphalt with properly graded sand and a mineral filler. The asphalt and sand should be heated separately to a temperture of from 275° F. to 325° F. The filler should be added to the hot sand and followed by the asphalt. The mixture should contain from 9 per cent to 12 per cent bitumen and will vary within these limits with the exact grading of the aggregate. After thorough mixing the hot mixture should be deposited in a uniform layer on a binder course which has been previously laid over a concrete base. It should be laid to such depth that it will yield a uniform layer 1½ or 2 inches in thickness as may be required after thorough rolling.

NA-9. FLUXED TRINIDAD ASPHALT FOR CONSTRUCTION.

General.

The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity, 25°/25° C. (77°/77° F.)____1.210 to 1.270
2. Flash point_____not less than 175° C. (347° F.)
3. Melting point_____50° C. (122° F.) to 60° C. (140° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec_____40 to 50
5. Loss at 163° C. (325° F.), 5 hours____not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec_____not less than 20
6. Total bitumen (soluble in carbon disulphide), not less than 65.0%
   b. Inorganic matter insoluble_____22.0% to 32.0%

Methods of testing.

Tests of the physical and chemical properties of the fluxed native asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test D 5–16.
5. Volatilization test, U. S. Department of Agriculture Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used for sheet asphalt construction in the southern United States or for the same type of construction in the northern United States to withstand very heavy traffic. It is intended to cover satisfactory grades of products prepared by fluxing Trinidad asphalt.

Sheet asphalt construction contemplates a mixture of the fluxed asphalt with properly graded sand and a mineral filler. The asphalt and sand should be heated separately to a temperature of from 275° F. to 325° F. The filler should be added to the hot sand and followed by the asphalt. The mixture should contain from 9 per cent to 12 per cent bitumen and will vary within these limits with the exact grading of the aggregate. After thorough mixing the hot mixture should be deposited in a uniform layer on a binder course which has been previously laid over a concrete base. It should be laid to such depth that it will yield a uniform layer $1\frac{1}{2}$ or 2 inches in thickness as may be required after thoroughly rolling.

TC–1. TAR FOR COLD APPLICATION.

General.

The tar shall be homogeneous.

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)--not less than 1.100
2. Specific viscosity at 40° C. (104° F.)----------8 to 13
3. Total distillate by weight:
   - To 170° C. (338° F.)----------not more than 5 per cent
   - To 270° C. (518° F.)----------not more than 30 per cent
   - To 300° C. (572° F.)----------not more than 40 per cent
4. Total bitumen (soluble in carbon disulphide), not less than 90%

Methods of testing.

Tests of the physical and chemical properties of the tar shall be made in accordance with the following methods:

1. Specific gravity, Department of Agriculture Bulletin 314, p. 4.
2. Specific viscosity (on first 50 c.c.) U. S. Department of Agriculture Bulletin 314, p. 7.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
4. Total bitumen (soluble in carbon disulphide) not less than 90%

   314, p. 25.

This specification provides primarily for a material to be used as a primer coat on macadam, gravel, or shell roads to be immediately followed by a more viscous product (Specification TH–1). It may be used alone for the cold surface treatment of the above types of road in the manner described under Specification TC–2, which provides for a material better adapted to this purpose. It may also be used for the maintenance of tar macadam or tar concrete roads. The specification is intended to cover gas house, coke oven, and water gas tar products.

If used as a primer coat, the road surface should be in a good state of repair, well consolidated, free from holes or depressions, and thoroughly swept for the removal of dust and detritus before the application is made. Newly constructed or reconstructed roads should be permitted to consolidate under traffic before the tar is applied. The tar may be applied without heating by a pressure distributer at a uniform rate of 0.2 to 0.3 gallon per square yard. The primer coat should be permitted to soak in undisturbed for from 18 to 24 hours, after which it should be given a very light covering of stons chips or fine gravel in just sufficient quantity to prevent the distributor wheels from picking up the surface. The second application should be a heavier tar (Specification TH–1). Roads having a double treatment as above described should yield somewhat longer service than those having only a single treatment. They may be maintained by subsequent hot or cold applications of tar (Specifications TH–1 or TC–2).

TC–2. TAR FOR COLD APPLICATION.

General. The tar shall be homogeneous.

Physical and chemical properties. It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.100 to 1.140
2. Specific viscosity at 40° C. (104° F.)_____25 to 35
3. Total distillate by weight:
   - To 170° C. (338° F.)_____not more than 2.0 per cent
   - To 270° C. (518° F.)_____not more than 25.0 per cent
   - To 300° C. (572° F.)_____not more than 35.0 per cent
4. Total bitumen (soluble in carbon disulphide)__ 95% to100%

Methods of testing. Tests of the physical and chemical properties of the tar shall be made in accordance with the following methods:

1. Specific gravity, Department of Agriculture Bulletin 314, p. 4.
2. Specific viscosity (on first 50 c. c.), U. S. Department of Agriculture Bulletin 314, p. 7.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides primarily for a material to be used in the surface treatment of macadam, gravel, or shell roads to form a thin wearing mat or carpet which may be built up by subsequent maintenance treatment of either the same type of material or a heavier product (Specification TH–1). It may also be used for maintenance of tar macadam or tar concrete roads, for which purpose it is considered preferable to specification TC–1. The specification is intended to cover water-gas tar and low carbon coke-oven tar products.

A successful treatment requires that the road surface shall be in a good state of repair, well consolidated, free from holes or depressions, and thoroughly swept for the removal of dust and detritus before the application is made. Newly constructed or reconstructed roads should be permitted to consolidate under traffic before the tar is applied. The tar may usually be applied without heating excepting when cold weather renders it too viscous to distribute properly. The initial application should be made by means of a pressure distributor at the rate of from one-third to one-half gallon per square yard. It should be covered with a uniform layer of dustless broken stone all of which will pass a one-half or three-quarter inch laboratory screen or pea gravel, which will pass a one-half inch laboratory screen in an amount just sufficient to absorb the bitumen and to prevent the surface from picking up under traffic. Subsequent applications may be made by a pressure distributor or by brooming the tar uniformly over the road surface. From one-tenth to one-fifth gallon per square yard will usually prove sufficient, and this may be covered with coarse sand or stone chips which will pass a one-half inch laboratory screen. Under favorable conditions a treatment should last throughout at least one season.

TC-3. TAR FOR COLD PATCHING.

General.

The tar shall be homogeneous.

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.100 to 1.200
2. Specific viscosity at 40° C. (104° F.)_____40 to 70
3. Total distillate by weight:
   - To 170° C. (338° F.)_____not less than 2.0 per cent
   - To 270° C. (518° F.)_____15 to 25 per cent
   - To 300° C. (572° F.)_____not more than 30.0 per cent
4. Total bitumen (soluble in carbon disulphide), not less than 80%

Methods of testing.

Tests of the physical and chemical properties of the tar shall be made in accordance with the following methods:

1. Specific gravity, Department of Agriculture Bulletin 314, p. 4.
2. Specific viscosity (on first 50 c. c.), U. S. Department of Agriculture Bulletin 314, p. 7.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the repair of surface breaks, holes and depressions in bituminous-bound and surface-treated roads. It is intended to cover preparations consisting of gas-house, coke-oven, or water-gas tars or pitches which have been rendered sufficiently fluid by the addition of distillates to enable them to be handled without heating.

For surface breaks and shallow depressions or those which in general do not exceed one-half inch in depth, a patch may be made by painting the bottom of the depression with the tar, and scattering over it a sufficient amount of stone chips to fill the depression.

In repairing deeper depressions and holes, the old material should be removed to yield a clean bottom. The sides of the hole should be cut approximately vertical. A mixture of graded broken stone with just a sufficient amount of tar to thoroughly coat each particle should be prepared, and firmly tamped into the hole to form a neat patch in the surface. A thin layer of sand or screenings over the patch will prevent it from picking up under traffic.

TH–1. REFINED TAR FOR HOT APPLICATION.

General. The refined tar shall be homogeneous and free from water.

Physical and chemical properties. It shall meet the following requirements:

1. Specific gravity 25°/25°C. (77°/77°F.)__not less than 1.130
2. Float test at 32°C. (90°F.)_____ 60 sec. to 150 sec.
3. Total distillate by weight:
   To 170°C. (338°F.)_____ not more than 1 per cent
   To 270°C. (518°F.)_____ not more than 15 per cent
   To 300°C. (572°F.)_____ not more than 25 per cent
4. Total bitumen (soluble in carbon disulphide), not less than 85 per cent

Methods of testing. Tests of the physical and chemical properties of the refined tar shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p 25.

This specification provides primarily for a material to be used in the surface treatment of macadam, gravel, or shell roads, either with or without a primer coat (Specification TC–1) to form a wearing mat or carpet. A primer coat is particularly desirable on gravel or shell roads. It may also be used for the maintenance of tar macadam or tar concrete roads. The specification is intended to cover gas-house, coke-oven, and water-gas tar products.

A successful treatment requires that the road surface shall be in a good state of repair, well consolidated, free from holes or depressions, and thoroughly swept for the removal of dust and detritus before the application is made, if a primer coat has not already been applied. Newly constructed and reconstructed roads should be permitted to consolidate under traffic before the tar is applied. The tar should be heated to a temperature of 200° F. to 250° F. before applying, and the application should be made by means of a pressure distributor at the rate of from one-third to one-half gallon per square yard. It should be covered with a uniform layer of dustless broken stone all of which will pass a 1-inch or three-quarter-inch laboratory screen or pea gravel which will pass a one-half-inch laboratory screen in an amount just sufficient to absorb the bitumen and to prevent the surface from picking up under traffic. Subsequent application may be made by a pressure distributor or by brooming the tar uniformly over the road surface. From one-tenth to one-fifth gallon per square yard will usually prove sufficient, and this may be covered with coarse sand or stone chips which will pass a half-inch laboratory screen. Under favorable conditions with occasional patching of any breaks in the surface a treatment should last for several years.

TP–1. REFINED TAR FOR CONSTRUCTION.

General.

The refined tar shall be homogeneous and free from water.

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.150 to 1.200
2. Float test at 50° C. (122° F.)_____90 sec. to 120 sec.
3. Total distillate by weight:
   To 170° C. (336° F.)_____not more than 1.0 per cent
   To 270° C. (518° F.)_____not more than 10.0 per cent
   To 300° C. (572° F.)_____not more than 20.0 per cent
   (*a*) Melting point of residue,
   not more than 65° C. (149° F.)
4. Total bitumen (soluble in carbon disulphide)__97% to 100%

Methods of testing.

Tests of the physical and chemical properties of the refined tar shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
   (*a*) Melting point, A. S. T. M. Tentative Standard D 36–16 T, Proc. A. S. T. M. 1916—p. 549.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the extreme northern United States. It is intended to cover refined water-gas tar products.

It should be applied at a temperature of from 250° F. to 300° F. to the upper or wearing course of compacted broken stone at the rate of from 1½ to 1¾ gallons per square yard. The application may be made by means of pouring pots or by a pressure distributor so designed that it will not produce ruts during application. The above quantities are based on a wearing course 3 inches in thickness before rolling, composed of a product which will pass a 2 to 3 inch laboratory screen and be retained on a 1-inch laboratory screen. The exact range in size should be governed by the kind and quality of rock used. The application should be followed by a sufficient amount of clean small-sized broken stone to fill the surface voids when thoroughly rolled. A seal coat of the same tar or of hot asphalt (Specification OA–6) should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with tar surface treatments, using the materials and methods given under Specifications TC–1, TC–2, or TH–1. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

TP–2. REFINED TAR FOR CONSTRUCTION.

General.

The refined tar shall be homogeneous and free from water. It shall meet the following requirements:

Physical and chemical properties.

1. Specific gravity 25° C./25° C. (77°/77° F.)---1.200 to 1.250
2. Float test at 50° C. (122° F.)----------90 sec. to 120 sec.
3. Total distillate by weight:
   - To 170° C. (338° F.)----------not more than 1.0 per cent
   - To 270° C. (518° F.)----------not more than 10.0 per cent
   - To 300° C. (572° F.)----------not more than 20.0 per cent

   a. Melting point of residue--not more than 65° C. (149° F.)
4. Total bitumen (soluble in carbon disulphide), 80 per cent to 97 per cent

Methods of testing.

Tests of the physical and chemical properties of the refined tar shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
   a. Melting point A. S. T. M. Tentative Standard D 36–16 T, Proc A. S. T. M., 1916, 549.
4. Total bitumen, U S Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam in the extreme northern United States. It is intended to cover refined gas-house or coke-oven tar.

It should be applied at a temperature of from 250° F. to 300° F. to the upper or wearing course of compacted broken stone at the rate of from 1½ to 1¾ gallons per square yard. The application may be made by means of pouring pots or by a pressure distributor so designed that it will not produce ruts during application. The above quantities are based on a wearing course 3 inches in thickness before rolling, composed of a product which will pass a 2 to 3 inch laboratory screen and be retained on a 1-inch laboratory screen. The exact range in size should be governed by the kind and quality of rock used. The application should be followed by a sufficient amount of clean small sized broken stone to fill the surface voids when thoroughly rolled. A seal coat of the same tar or of hot asphalt (Specification OA–6) should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with tar surface treatments, using the materials and methods given under specifications TC–1, TC–2, or TH–1. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

TP–3. REFINED TAR FOR CONSTRUCTION.

General.

The refined tar shall be homogeneous and free from water. It shall meet the following requirements:

Physical and chemical properties.

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.150 to 1.200
2. Float test at 50° C. (122° F.)_____120 sec. to 150 sec.
3. Total distillate by weight:
   - To 170° C. (338° F.)_____not more than 1.0 per cent
   - To 270° C. (518° F.)_____not more than 10.0 per cent
   - To 300° C. (572° F.)_____not more than 20.0 per cent
   - *a.* Melting point of residue, not more than 65° C. (149° F.)
4. Total bitumen (soluble in carbon disulphide)__97% to 100%

Methods of testing.

Tests of the physical and chemical properties of the refined tar shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
   - *a.* Melting point, A. S. T. M. Tentative Standard D 36–16 T. Proc. A. S. T. M. 1916, p. 549.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam or one-size-stone bituminous concrete in the northern United States. It is intended to cover refined water-gas tar products.

In bituminous macadam construction it should be applied in the manner outlined under Specification TP–2.

One-size-stone bituminous concrete contemplates a mixture of the tar with a crusher product passing a 1¼ inch screen and retained upon a ½ inch screen. The tar should be heated to a temperature of from 225° F., to 275° F., and the crushed stone to a temperature of from 150° F., to 250° F., before mixing. The mixture should contain from 5 per cent to 7 per cent bitumen and will vary within these limits with the character of the rock and the exact grading of the aggregate. The hot mixture should be deposited in a uniform layer over a concrete or well compacted broken stone or gravel foundation to such depth that it will yield a uniform layer two inches in thickness after thorough rolling. A seal coat of the same tar or of hot asphalt (Specification OA–6) should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with tar surface treatments using the materials and methods given under Specifications TC–1, TC–2, or TH–1. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing course rock.

TP–4. REFINED TAR FOR CONSTRUCTION.

General. The refined tar shall be homogeneous and free from water.

Physical and chemical properties. It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.200 to 1.250
2. Float test at 50° C. (122° F.)_____120 sec. to 150 sec.
3. Total distillate by weight:
   To 170° C. (338° F.)_____not more than 1.0 per cent
   To 270° C. (518° F.)_____not more than 10.0 per cent
   To 300° C. (572° F.)_____not more than 20.0 per cent
   a. Melting point of residue not more than 65° C. (149° F.)
4. Total bitumen (soluble in carbon disulphide)__80% to 97%

Methods of testing. Tests of the physical and chemical properties of the refined tar shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
3. Distillation tests, A. S. T. M. Standard Test D20–16.
   a. Melting point, A. S. T. M. Tentative Standard D36–16 T, Proc. A. S. T. M. 1916, p. 549.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam or one size stone bituminous concrete in the northern United States. It is intended to cover refined gas-house or coke-oven tar.

In bituminous macadam construction it should be applied in the manner outlined under Specification TP–2.

One-size stone bituminous concrete contemplates a mixture of the tar with a crusher product passing a 1¼-inch screen and retained upon a one-half-inch screen. The tar should be heated to a temperature of from 225° F. to 275° F. and the crushed stone to a temperature of from 150° F. to 250° F. before mixing. The mixture should contain from 5 per cent to 7 per cent bitumen, and will vary within these limits with the character of the rock and the exact grading of the aggregate. The hot mixture should be deposited in a uniform layer over a concrete or well compacted broken stone or gravel foundation to such depth that it will yield a uniform layer 2 inches in thickness after thorough rolling. A seal coat of the same tar or of hot asphalt (Specification OA–6) should then be applied at the rate of 0.4 to 0.6 gallon per square yard and covered with a sufficient amount of stone chips to just absorb the excess bitumen. Roads of this character may be maintained with tar surface treatments, using the materials and methods given under Specifications TC–1, TC–2, or TH–1. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing-course rock.

TP–5. REFINED TAR FOR CONSTRUCTION.

General.

The refined tar shall be homogeneous and free from water.

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity, 25°/25° C. (77°/77° F.)_____1.150 to 1.200
2. Float test at 50° C (122° F.)_____150 sec. to 180 sec.
3. Total distillate by weight:
   - To 170° C. (338° F.)_____not more than 1.0 per cent
   - To 270° C. (518° F.)_____not more than 10.0 per cent
   - To 300° C. (572° F.)_____not more than 20.0 per cent
   - *a.* Melting point of residue, not more than 65° C. (149° F.)
4. Total bitumen (soluble in carbon disulphide)__97% to 100%

Methods of testing.

Tests of the physical and chemical properties of the refined tar shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
   - *a.* Melting point, A. S. T. M. Tentative Standard D 36–10 T, Proc. A. S. T. M. 1916, p. 549.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam or one size stone bituminous concrete in the southern United States. It is intended to cover refined water-gas tar products.

In bituminous macadam construction it should be applied in the manner outlined under Specification TP–2.

In one size stone bituminous-concrete construction it should be used in the manner outlined under Specification TP–4.

In either type of construction the tar should be heated to from 250° F. to 300° F. Roads of this character may be maintained with tar surface treatments, using the materials and methods given under Specifications TC–1, TC–2, or TH–1. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing-course rock.

TP–6. REFINED TAR FOR CONSTRUCTION.

General.

The refined tar shall be homogeneous and free from water.

Physical and chemical properties.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)_____1.200 to 1.250
2. Float test at 50° C. (122° F.)_____150 sec. to 180 sec.
3. Total distillate by weight:
   - To 170° C. (338° F.)_____not more than 1.0 per cent
   - To 270° C. (518° F.)_____not more than 10.0 per cent
   - To 300° C. (572° F.)_____not more than 20.0 per cent
   - *a.* Melting point of residue, not more than 65° C. (149° F.)
4. Total bitumen (soluble in carbon disulphide)__80% to 97%

Methods of testing.

Tests of the physical and chemical properties of the refined tar shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture Bulletin 314, p. 5.
2. Float test, U. S. Department of Agriculture Bulletin 314, p. 9.
3. Distillation test, A. S. T. M. Standard Test D 20–16.
   - *a.* Melting point, A. S. T. M. Tentative Standard D 36–16 T, Proc. A. S. T. M. 1916, p. 549.
4. Total bitumen, U. S. Department of Agriculture Bulletin 314, p. 25.

This specification provides for a material to be used in the construction of bituminous macadam or one-size stone bituminous concrete in the southern United States. It is intended to cover refined gas-house or coke-oven tar.

In bituminous-macadam construction it should be applied in the manner outlined under Specification TP–2.

In one size stone bituminous-concrete construction it should be used in the manner outlined under Specification TP–4.

In either type of construction the tar should be heated to from 250° F. to 300° F. Roads of this character may be maintained with tar surface treatments, using the materials and methods given under Specifications TC–1, TC–2, or TH–1. Such maintenance treatments should be applied whenever the wear comes directly upon the wearing-course rock.

METHODS OF TESTING.

The following methods of testing are those to which reference is made in the foregoing specifications. The descriptions taken from Department of Agriculture Bulletin 314 have been condensed, but not changed in any essential particular unless so indicated in the specifications proper.

SPECIFIC GRAVITY.

[Bulletin 314, p. 4.]

HYDROMETER METHOD.

A sufficient quantity of material is poured into a tin cup, which is then placed in a large dish containing cold or warm water as occasion may require. The material in the cup should be stirred with a thermometer until it is brought to a temperature of 25° C., after which it should be immediately poured into a hydrometer jar and its gravity determined by means of the proper hydrometer. In case the hydrometer sinks slowly, owing to the viscosity of the material, it should be given sufficient time to come to a definite resting point, and this point should be checked by raising the hydrometer and allowing it to sink a second time. The hydrometer should never be pushed below the point at which it naturally comes to rest until the last reading has been made. It may then be pushed below the reading for a distance of three or four of the small divisions on the scale, whereupon it should immediately begin to rise. If it fails to do so, the material is too viscous for the hydrometer method, and the pycnometer method should be employed.

The direct specific gravity reading obtained by the foregoing method is based upon water at 15.5° C. taken as unity. For all practical purposes this reading may be corrected to water at 25° C., considered as unity, by multiplying it by 1.002. Thus:

Specific gravity 25° C./25° C.=specific gravity 25° C./15.5° C.×1.002.

SPECIFIC GRAVITY.

[Bulletin 314, p. 5.]

PYCNOMETER METHOD.

The pycnometer, shown in figure 1, consists of a fairly heavy, straight-walled glass tube, 70 millimeters long and 22 millimeters in diameter, carefully ground to receive an accurately fitting solid glass stopper with a hole of 1.6 millimeters bore in place of the usual capillary opening. The lower part of this stopper is made concave in order to allow all air bubbles to escape through the bore. The depth of the cup-shaped depression is 4.8 millimeters at the center. The stoppered tube has a capacity of about 24 cubic centimeters and when empty weighs about 28 grams.

The clean, dry pycnometer is first weighed empty and this weight is called "a". It is then filled in the usual manner with freshly distilled water at 25° C., and the weight is again taken and called "b". A small amount of the bitumen should be placed in a spoon and brought to a fluid condition by the gentle application of heat, with care that no loss by evaporation occurs. When sufficiently fluid, enough is poured into the dry pycnometer, which may also be

warmed, to fill it about half full, without allowing the material to touch the sides of the tube above the desired level. The tube and contents are then allowed to cool to room temperature, after which the tube is carefully weighed with the stopper. This weight is called "c". Distilled water, at 25° C., is then poured in until the pycnometer is full. After this the stopper is inserted, and the whole cooled to 25° C. by a 30-minute immersion in a beaker of distilled water maintained at this temperature. All surplus moisture is then removed with a soft cloth, and the pycnometer and contents are weighed. This weight is called "d". From the weights obtained the specific gravity of the bitumen may be readily calculated by the following formula:

FIG. 1.—Pycnometer (Hubbard type).

$$\text{Specific gravity } 25°\text{ C.}/25°\text{ C.} = \frac{c-a}{(b-a)-(d-c)}$$

The specific gravity of fluid bitumen may be determined in the ordinary manner with this pycnometer by completely filling it with the material and dividing the weight of the bitumen thus obtained by that of the same volume of water.

FLASH POINT.

[Bulletin 314, p. 17.]

OPEN-CUP METHOD.

The open-cup oil tester, shown in figure 2, consists of a brass oil cup *a* of about 100 cubic centimeters capacity, and an outer vessel *b* which serves as an air jacket; a suitable thermometer *c* is suspended from the wire support *d* directly over the center of the cup so that its bulb is entirely covered with oil but does not touch the bottom of the cup. The testing flame is obtained from a jet of gas passed through a piece of glass tubing, and should be about 5 millimeters in length.

The test is made by first filling the oil cup with the material under examination to within about 5 millimeters of the top. The Bunsen flame is then applied in such a manner that the temperature of the material in the cup is raised at the rate of 5° C. per minute. From time to time the testing flame is brought almost in contact with the surface of the oil. A distinct flicker or flash over the entire surface of the oil shows that the flash point is reached and the temperature at this point is taken.

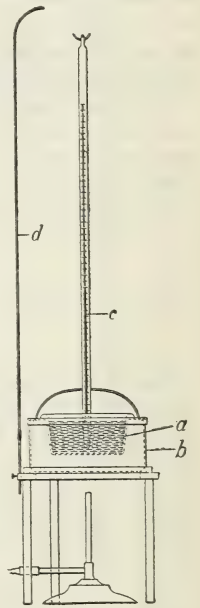

FIG. 2.—Open-cup oil tester.

SPECIFIC VISCOSITY.

[Bulletin 314, p. 7.]

ENGLER VISCOSIMETER METHOD.

The specific viscosity of fluid bituminous road materials is determined at the specified temperature by means of the Engler viscosimeter. This apparatus shown in figure 3 may be described as follows: *a* is a brass vessel for holding the material to be tested, and may be closed by the cover *b*. To the conical bottom of *a* is fitted a conical outflow tube *c*, exactly 20 millimeters long, with a diameter at the top of 2.9 millimeters and at the bottom of 2.8 millimeters. This tube may be closed and opened by the

pointed hardwood stopper *d*. Pointed metal projections are placed on the inside of *a* at equal distances from the bottom and serve for measuring the charge of material, which is 240 cubic centimeters. The thermometer *e* is used to ascertain the temperature of the material to be tested. The vessel *a* is surrounded by a brass jacket *f*, which holds the material used as a heating bath, either water or cottonseed oil, according to the temperature at which the test is to be made. A tripod *g* serves as a support for the apparatus and also carries a ring burner *h* by means of which the bath is directly heated. The measuring cylinder of 100 cubic centimeters capacity, which is sufficiently accurate for work with road materials, is placed directly under the outflow tube.

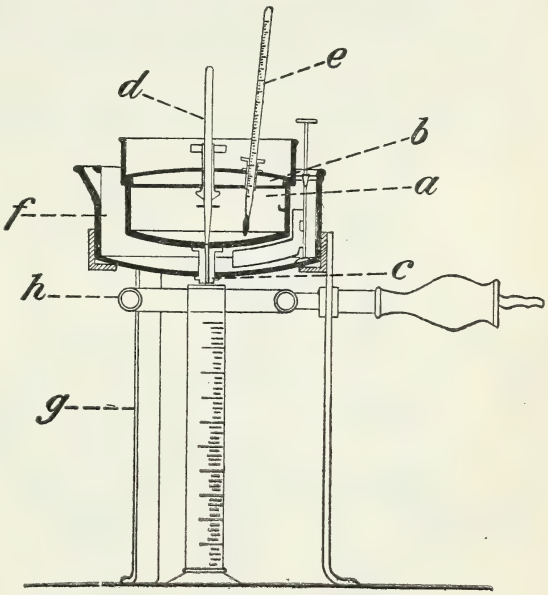

FIG. 3.—Engler viscosimeter.

As all viscosity determinations should be compared with that of water at 25° C., the apparatus should be previously calibrated as follows: The cup and outlet tube should first be scrupulously cleaned. A piece of soft tissue paper is convenient for cleaning the latter. The stopper is then inserted in the tube and the cup filled with water at 25° C. to the top of the projections. The measuring cylinder should be placed directly under the outflow tube so that the material, upon flowing out, will not touch the sides, and the stopper may then be removed. The time required for 50 cubic centimeters to run out should be ascertained by means of a stop watch and the results so obtained should be checked a number of times. The time should be about 11 seconds.

Bituminous road materials are tested in the same manner as water and the temperature at which the test is made is controlled by the bath. The material should be brought to the desired temperature and maintained there for at least three minutes before making the test. The results are expressed as specific viscosity compared with water at 25° C., as follows:

$$\text{Specific viscosity at a° C.} = \frac{\text{seconds for passage of given volume at a° C.}}{\text{seconds for passage of same volume of water at 25° C.}}$$

VOLATILIZATION TEST.

[Bulletin 314, p. 19.]

The oven shown in figure 4, known as the New York testing laboratory oven, is used by the office of public roads and rural engineering, although any other form may be used that will give a uniform temperature throughout all parts where samples are placed. The bulb of one of the termometers is immersed

in a sample of some fluid, nonvolatile bitumen, while the other is kept in air at the same level. The first thermometer serves to show the temperature of the samples during the test, while the latter gives prompt warning of any sudden changes in temperature due to irregularities in the gas pressure, etc.

Before making the test the interior of the oven should show a temperature of 163° C. as registered by the thermometer in air. A round tin box[1] 6 centimeters in diameter and 2 centimeters deep is accurately weighed after carefully wiping with a towel to remove any grease or dirt. About 20 grams of the material to be tested is then placed in the box. The material may then be weighed on a rough balance, if one is at hand, after which the accurate weight, which should not vary more than 0.2 gram from the specified amount is obtained. It may be necessary to warm some of the material in order to handle it conveniently, after which it must be allowed to cool before determining the accurate weight.

The sample should now be placed in the oven, where it is allowed to remain for a period of five hours, during which time the temperature as shown by the thermometer in bitumen should not vary at any time more than 2° C. from 163° C. The sample is then removed from the oven, allowed to cool, and reweighed. From the difference between this weight and the total weight before heating, the percentage of loss on the amount of material taken is calculated.

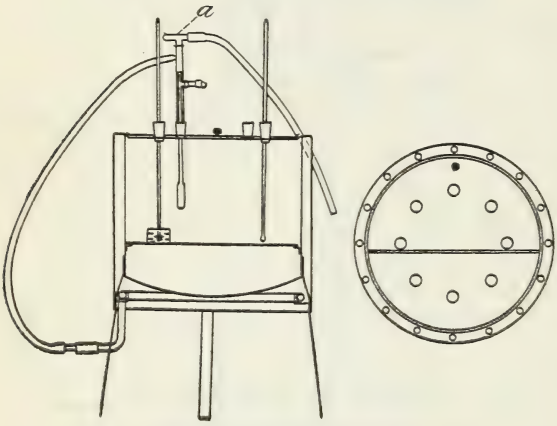

FIG. 4.—New York Testing Laboratory oven.

Highly volatile and nonvolatile materials should not be subjected to this test at the same time in the same oven, owing to a tendency on the part of the latter to absorb some of the volatile products of the former.

Some relative idea of the amount of hardening which has taken place may be obtained from the results of a float or penetration test made on the residue, as compared with the results of the same tests on the original sample. Before any tests are made on the residue, it should be melted and thoroughly stirred while cooling.

FLOAT TEST.

[Bulletin 314, p. 9.]

NEW YORK TESTING LABORATORY FLOAT APPARATUS.

The float apparatus consists of two parts, an aluminum float or saucer and a conical brass collar (fig. 5). The two parts are made separately, so that one float may be used with a number of brass collars.

In making the test the brass collar *b* is placed with the small end down on a brass plate, which has been previously amalgamated with mercury by first

[1] The box for a 50-gram sample should be 5½ centimeters in diameter and 3½ centimeters deep.

rubbing it with a dilute solution of mercuric chloride or nitrate and then with mercury. A small quantity of the material to be tested is heated in a metal spoon until quite fluid, with care that it suffers no appreciable loss by volatilization and that it is kept free from air bubbles. It is then poured into the collar in a thin stream until slightly more than level with the top. The surplus may be removed, after the material has cooled to room temperature, by means of a spatula or steel knife, which has been slightly heated. The collar and plate are then placed in a tin cup containing ice water maintained at 5° C., and left in this bath for at least 15 minutes. Meanwhile another cup of 1 quart capacity is filled about three-fourths full of water and placed on a tripod, and the water is heated to the specified temperture at which the test is to be made. This temperature should be accurately maintained, and should at no time throughout the entire test be allowed to vary more than one-half a degree centigrade from the temperature specified. After the material to be tested has been kept in the ice water for at least 15 minutes, the collar with its contents

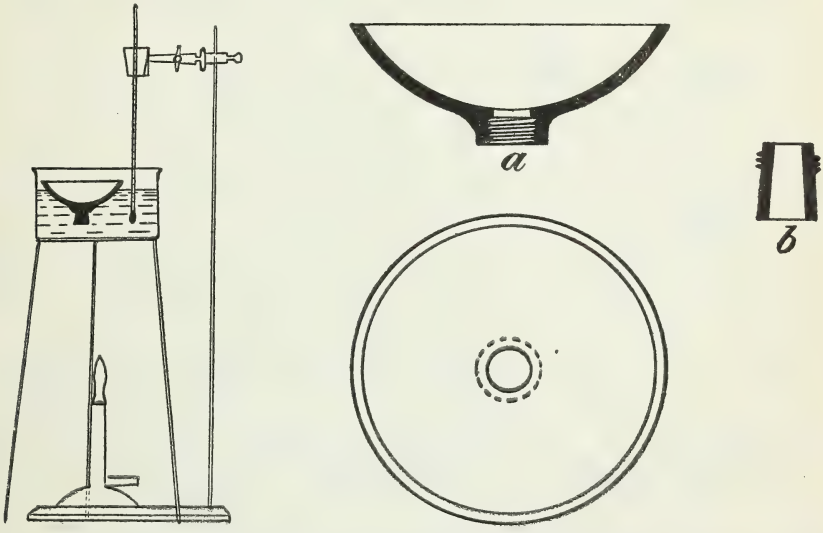

FIG. 5.—New York Testing Laboratory float apparatus.

is removed from the plate and screwed into the aluminum float *a*, which is then immediately floated in the warmed bath. As the plug of bituminous material becomes warm and fluid, it is gradually forced upward and out of the collar, until water gains entrance to the saucer and causes it to sink.

The time in seconds between placing the apparatus on the water and when the water breaks through the bitumen is determined by means of a stop watch, and is taken as a measure of the consistency of the material under examination.

TOTAL BITUMEN.

[Bulletin 314, p. 25.]

GOOCH CRUCIBLE METHOD.

This test consists in dissolving the bitumen in carbon disulphide and recovering any insoluble matter by filtering the solution through an asbestos felt. The form of Gooch crucible best adapted for the determination is 4.4 centi-

meters wide at the top, tapering to 3.6 centimeters at the bottom, and is 2.5 centimeters deep.

For preparing the felt the necessary appartatus is arranged as shown in figure 6, in which *a* is the filtering flask, *b* a rubber stopper, *c* the filter tube, and *d* a section of rubber tubing which tightly clasps the Gooch crucible *c*. The asbestos is cut with scissors into pieces not exceeding 1 centimeter in length, after which it is shaken up with just sufficient water to pour easily. The crucible is filled with the suspended asbestos, which is allowed to settle for a few moments. A light suction is then applied to draw off all the water and leave a firm mat of asbestos in the crucible. More of the suspended material is added, and the operation is repeated until the felt is so dense that it scarcely transmits light when held so that the bottom of the crucible is between the eye and the source of light. The felt should then be washed several times with water and drawn firmly against the bottom of the crucible by an increased suction. The crucible is removed to a drying oven for a few minutes, after which it is ignited at red heat over a Bunsen burner, cooled in a desiccator, and weighed.

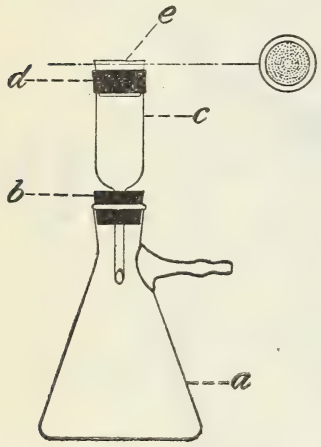

FIG. 6.—Apparatus for determining soluble bitumen.

From 1 to 2 grams of the bituminous material is now placed in the Erlenmeyer flask, which has been previously weighed, and the accurate weight of the sample is obtained. One hundred cubic centimeters of chemically pure carbon disulphide is poured into the flask in small portions, with continual agitation, until all lumps disappear and nothing adheres to the bottom. The flask is then corked and set aside for 15 minutes.

After being weighed, the Gooch crucible containing the felt is set up over the dry pressure flask, as shown in the figure, and the solution of bitumen in carbon disulphide is decanted through the felt without suction by gradually tilting the flask, with care not to stir up any precipitate that may have settled out. At the first sign of any sediment coming out, the decantation is stopped and the filter allowed to drain. A small amount of carbon disulphide is then washed down the sides of the flask, after which the precipitate is brought upon the felt and the flask scrubbed, if necessary, with a feather or "policeman," to remove all adhering material. The contents of the crucible are washed with carbon disulphide, until the washings run colorless. Suction is then applied until there is practically no odor of carbon disulphide in the crucible, after which the outside of the crucible is cleaned with a cloth moistened with a small amount of the solvent. The crucible and contents are dried in a hot-air oven at 100° C. for about 20 minutes, cooled in a desiccator, and weighed. If any appreciable amount of insoluble matter adheres to the flask, it should also be dried and weighed, and any increase over the original weight of the flask should be added to the weight of insoluble matter in the crucible. The total weight of insoluble material may include both organic and mineral matter. The former, if present, is burned off by ignition at a red heat until no incandescent particles remain, thus leaving the mineral matter or ash, which can be weighed on cooling. The difference between the total weight of material insoluble in carbon disulphide and the weight of substance taken equals the total bitumen, and the percentage weights are calculated and reported as total

bitumen, and organic and inorganic matter insoluble, on the basis of the weight of material taken for analysis.

This method is quite satisfactory for straight oil and tar products, but where certain natural asphalts are present it will be found practically impossible to retain all of the finely divided mineral matter on an asbestos felt. It is, therefore, generally more accurate to obtain the result for total mineral matter by direct ignition of a 1-gram sample in a platinum crucible. The total bitumen is then determined by deducting from 100 per cent the sum of the percentages of total mineral matter and organic matter insoluble. If the presence of a carbonate mineral is suspected, the percentage of mineral matter may be most accurately obtained by treating the ash from the fixed carbon determination with a few drops of ammonium carbonate solution, drying at 100° C., then heating for a few minutes at a dull red heat, cooling, and weighing again.

When difficulty in filtering is experienced—for instance, when Trinidad asphalt is present in any amount—a period of longer subsidence than 15 minutes is necessary, and the following method proposed by the Committee on Standard Tests for Road Materials of the American Society of Testing Materials is recommended:[1]

From 2 to 15 grams (depending on the richness in bitumen of the substance) is weighed into a 150-cubic centimeter Erlenmyer flask, the tare of which has been previously assertained, and treated with 100 cubic centimeters of carbon disulphide. The flask is then loosely corked and shaken from time to time until practically all large particles of the material have been broken up, when it is set aside and not disturbed for 48 hours. The solution is then decanted off into a similar flask that has been previously weighed, as much of the solvent being poured off as possible without disturbing the residue. The first flask is again treated with fresh carbon disulphide and shaken as before, when it is put away with the second flask and not disturbed for 48 hours.

At the end of this time the contents of the two flasks are carefully decanted off upon a weighed Gooch crucible fitted with an asbestos filter, the contents of the second flask being passed through the filter first. The asbestos filter shall be made of ignited long-fiber amphibole, packed in the bottom of a Gooch crusible to the depth of not over one-eighth of an inch. After passing the contents of both flasks through the filter, the two residues are shaken with more fresh carbon disulphide and set aside for 24 hours without disturbing, or until it is seen that a good subsidation has taken place, when the solvent is again decanted off upon the filter. This washing is continued until the filtrate or washings are practically colorless.

The crucible and both flasks are then dried at 125° C. and weighed. The filtrate containing the bitumen is evaporated, the bituminous residue burned, and the weight of the ash thus obtained added to that of the residue in the two flasks and the crucible. The sum of these weights deducted from the weight of substance taken gives the weight of bitumen extracted.

BITUMEN INSOLUBLE IN NAPHTHA.

[Bulletin 314, p. 28.]

GOOCH CRUCIBLE METHOD.

This determination is made in the same general manner as the total bitumen determination, except that 100 cubic centimeters of 86° to 88° B. paraffin naphtha, at least 85 per cent distilling between 35° C. and 65° C., is employed as a solvent instead of carbon disulphide. Considerable difficulty is sometimes

[1] Proc. Am. Soc. for Testing Materials, 1909, Vol. IX, p. 221.

experienced in breaking up some of the heavy semisolid bitumens; the surface of the material is attacked, but it is necessary to remove some of the insoluble matter in order to expose fresh material to the action of the solvent. It is, therefore, advisable to heat the sample after it is weighed, allowing it to cool in a thin layer around the lower part of the flask. If difficulty is still experienced in dissolving the material, a rounded glass rod will be found convenient for breaking up the undissolved particles. Not more than one-half of the total amount of naphtha required should be used until the sample is entirely broken up. The balance of the 100 cubic centimeters is then added, and the flask is twirled a moment in order to mix the contents thoroughly, after which it is corked and set aside for 30 minutes.

In making the filtration the utmost care should be exercised to avoid stirring up any of the precipitate, in order that the filter may not be clogged and that the first decantation may be as complete as possible. The sides of the flask should then be quickly washed down with naphtha and, when the crucible has drained, the bulk of insoluble matter is brought upon the felt. Suction may be applied when the filtration by gravity almost ceases, but should be used sparingly, as it tends to clog the filter by packing the precipitate too tightly. The material on the felt should never be allowed to run entirely dry until the washing is completed, as shown by the colorless filtrate. When considerable insoluble matter adheres to the flask no attempt should be made to remove it completely. In such cases the adhering material is merely washed until free from soluble matter, and the flask is dried with the crucible at 100° C. for about one hour, after which it is cooled and weighed. The percentage of bitumen insoluble is reported upon the basis of total bitumen taken as 100.

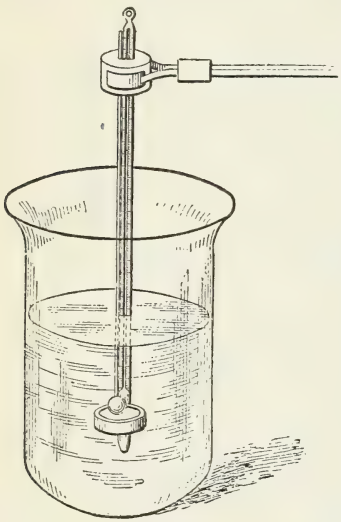

FIG. 7.

The difference between the material insoluble in carbon disulphide and in the naphtha is the bitumen insoluble in the latter. Thus, if in a certain instance it is found that the material insoluble in carbon disulphide amounts to 1 per cent and that 10.9 per cent is insoluble in naphtha, the percentage of bitumen insoluble would be calculated as follows:

$$\frac{\text{Bitumen insoluble in naphtha}}{\text{Total bitumen}} = \frac{10.9-1}{100-1} = \frac{9.9}{99} = 10 \text{ per cent}$$

MELTING POINT.

[A. S. T. M. Tentative Standard D36–16T.]

1. The ring and ball method shall be used. (Fig. 7.)

2. The apparatus shall consist of a brass ring 15.875 mm. (five-eighths inch) in diameter, 6.35 mm. (one-fourth inch) deep, 2.38125 (three thirty-seconds inch) wall, suspended 25.40 mm. (one inch) above bottom of beaker; a steel ball 9.525 mm. (three-eighths inch) in diameter, weighing between 3.45 and 3.50 g.; a standardized thermometer; a glass beaker, approximately 600 cc. capacity.

3. Carefully melt the sample and fill the ring with the material to be tested. Remove any excess. Place the ball in the center of the ring and suspend in the

beaker containing approximately 400 cc. of water at a temperature of 5° C. (41° F.). Arrange the thermometer bulb within ½ inch of the sample and at the same level. Apply heat *uniformly* over bottom of the beaker in quantity sufficient to raise the temperature 5° C. (9° F.) per minute. Record the temperature at starting the test and every minute thereafter until the test is completed. The rate of heating is very important. The softening point is the temperature at which the specimen has dropped 1 inch. Successive tests should average within 3° C. For temperatures above 90° C., glycerin shall be used instead of water.

PENETRATION.

[A. S. T. M. Standard Test D5–16.]

I. DEFINITION.

1. *Penetration.*—Penetration is defined as the consistency of a bituminous material expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time and temperature. Where the conditions of test are not specifically mentioned, the load, time and temperature are understood to be 100 g., 5 seconds, 25° C. (77° F.), respectively, and the units of penetration to indicate hundredths of a centimeter.

II. APPARATUS.

2. *Container.*—The container for holding the material to be tested shall be a flat-bottom, cylindrical dish, 55 mm. (2 3/16 inches) in diameter and 35 mm. (1⅜ inches) deep.[1]

3. *Needle.*—The needle[2] for this test shall be of cylindrical steel rod 50.8 mm. (2 inches) long and having a diameter of 1.016 mm. (0.04 inches) and turned on one end to a sharp point having a taper of 6.35 mm. (¼ inch).

4. *Water bath.*—The water bath shall be maintained at a temperature not varying more than 0.1° C. from 25° C. (77° F.). The volume of water shall be not less than 10 liters and the sample shall be immersed to a depth of not less than 10 cm. (4 inches) and shall be supported on a perforated shelf not less than 5 cm. (2 inches) from the bottom of the bath.

5. *Apparatus for penetration.*—Any apparatus which will allow the needle to penetrate without appreciable friction, and which is accurately calibrated to yield results in accordance with the definition of penetration, will be acceptable.

6. *Transfer dish for container.*—The transfer dish for container shall be a small dish or tray of such capacity as will insure complete immersion of the container during the test. It shall be provided with some means which will insure a firm bearing and prevent rocking the container.

III. PREPARATION OF SAMPLE.

7. *Preparation of sample.*—The sample shall be completely melted at the lowest possible temperature and stirred thoroughly until it is homogeneous and free from air bubbles. It shall then be poured into the sample container to a depth of not less than 15 mm. (⅝ inch). The sample shall be protected from dust and allowed to cool in an atmosphere not lower than 18° C. (65° F.) for one hour. It shall then be placed in the water bath along with the transfer dish and allowed to remain one hour.

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[1] This requirement is fulfilled by the American Can Co.'s gill style ointment box, deep pattern, 3-ounce capacity.

[2] Journal of Agricultural Research, Vol. V, No. 24, pp. 1125–1126.

IV. TESTING.

8. *Testing.*—(*a*) In making the test the sample shall be placed in the transfer dish filled with water from the water bath of sufficient depth to completely cover the container. The transfer dish containing the sample shall then be placed upon the stand of the penetration machine. The needle, loaded with specified weight, shall be adjusted to make contact with the surface of the sample. This may be accomplished by making contact of the actual needle point with its image reflected by the surface of the sample from a properly placed source of light. Either the reading of the dial shall then be noted or the needle brought to zero. The needle is then released for the specified period of time, after which the penetration machine is adjusted to measure the distance penetrated.

At least three tests shall be made at points on the surface of the sample not less than 1 cm. (⅜ inch) from the side of the container and not less than 1 cm. (⅜ inch) part. After each test the sample and transfer dish shall be returned to the water bath and the needle shall be carefully wiped toward its point with a clean, dry cloth to remove all adhering bitumen. The reported penetration shall be the average of at least three tests whose values shall not differ more than four points between maximum and minimum.

(*b*) When desirable to vary the temperature, time and weight and, in order to provide for a uniform method of reporting results when variations are made, the samples shall be melted and cooled in air as above directed. They shall then be immersed in water or brine, as the case may require, for one hour at the temperature desired. The following combinations are suggested:

At 0° C. (32° F.) 200-g. weight, 60 seconds.

At 46.1° C. (115° F.) 50-g. weight, 5 seconds.

DISTILLATION TEST.

[A. S. T. M. Standard Test D20–16. With tentative revision in thermometer requirements recommended by committee D–4 in 1917.]

1. *Sampling.*—The sample as received shall be thoroughly stirred and agitated, warming, if necessary, to insure a complete mixture before the portion for analysis is removed.

2. *Dehydration.*—If the presence of water is suspected or known, the material shall be dehydrated before distillation. About 500 cc. of the material are placed in an 800-cc. copper still provided with a distilling head connected with a water-cooled condenser. A ring burner is used, starting with a small flame at the top of the still, and gradually lowering it, if necessary, until all the water has been driven off. The distillate is collected in a 200-cc. separatory funnel with the tube cut off close to the stopcock. When all the water has been driven over and the distillate has settled out, the water is drawn off and the oils returned to the residue in the still. The contents of the still shall have cooled to below 100° C. before the oils are returned, and they shall be well stirred and mixed with the residue.

3. *Apparatus.*—The apparatus shall consist of the following standard parts:

(*a*) Flask: The distillation flask shall be a 250-cc. Engler distilling flask, having the following dimensions:

Diameter of bulb	cm.	8.0
Length of neck	cm.	15.0
Diameter of neck	cm.	1.7
Surface of material to lower side of tubulature	cm.	11.0
Length of tubulature	cm.	15.0
Diameter of tubulature	cm.	0.9
Angle of tubulature	deg.	75

A variation of 3 per cent from the above measurements will be allowed.

(*b*) Thermometer: The thermometer shall conform to the following requirements:

It shall be made of thermometric glass of a quality equivalent to suitable grades of Jena or Corning make. It shall be thoroughly annealed. It shall be filled above the mercury with inert gas which will not act chemically on or contaminate the mercury. The pressure of the gas shall be sufficient to prevent separation of the mercury column at all temperatures of the scale. There shall be a reservoir above the final graduation large enough so that the pressure will not become excessive at the highest temperature. The thermometer shall be finished at the top with a small glass ring or button suitable for attaching a tag. Each thermometer shall have for identification the maker's name, a serial number, and the letters "A. S. T. M. Distillation."

The thermometer shall be graduated from 0 to 400° C. at intervals of 1° C. Every fifth graduation shall be longer than the intermediate ones, and every tenth graduation beginning at zero shall be numbered. The graduation marks and numbers shall be clear-cut and distinct.

The thermometer shall conform to the following dimensions:

Total length, maximum, 385 mm.
Diameter of stem, 7 mm.; permissible variation, 0.5 mm.
Diameter of bulb, minimum, 5mm.; and shall not exceed diameter of stem.
Length of bulb, 12.5 mm.; permissible variation, 2.5 mm.
Distance from 0° to bottom of bulb, 30 mm.; permissible variation, 5 mm.
Distance from 0° to 400°, 295 mm.; permissible variation, 10 mm.

The accuracy of the thermometer when delivered to the purchaser shall be such that when tested at full immersion the maximum error from 0 to 200° C. shall not exceed the following:

From 0 to 200° C	0°.5 C.
From 200 to 300° C	1°.0 C.
From 300 to 375° C	1°.5 C.

The sensitiveness of the thermometer shall be such that when cooled to a temperature of 74° C. below the boiling point of water at the barometric pressure, at the time of test, and plunged into free flow of stream, the meniscus shall pass the point 10° C. below the boiling point of water in not more than six seconds.

The thermometer shall be set up as for the distillation test, using water, naphthalene and benzophenone as distilling liquids. The correctness of the thermometer shall be checked at 0 and 100° C. after each third distillation until seasoned.

(*c*) Condenser: The condenser tube shall have the following dimensions:

Adapter	mm	70
Length of straight tube	"	185
Width of tube	"	12–15
Width of adapter end of tube	"	20–25

(*d*) Stands: Two iron stands shall be provided, one with a universal clamp for holding the condenser, and one with a light grip arm with a cork-lined clamp for holding flask.

(*e*) Burner and shield: A Bunsen burner shall be provided, with a tin shield 20 cm. long by 9 cm. in diameter. The shield shall have a small hole for observing the flame.

(*f*) Cylinders: The cylinders used in collecting the distillate shall have a capacity of 25 cc., and shall be graduated in 0.1 cc.

4. *Setting up the apparatus.*—The apparatus shall be set up as shown in figure 8, the thermometer being placed so that the top of the bulb is opposite the middle of the tubulature. All connections should be tight.

5. *Method.*—One hundred cubic centimeters of the dehydrated material to be tested shall be placed in a tared flask and weighed. After adjusting the thermometer, shield, condenser, etc., the distillation is commenced, the rate being so regulated that 1 cc. passes over every minute. The receiver is changed as the mercury column just passes the fractionating point.

The following fractions should be reported:

Start of distillation to 100° C.
110 to 170° C.
170 to 235° C.
235 to 270° C.
270 to 300° C.
Residue.

To determine the amount of residue, the flask is weighed again when distillation is complete. During the distillation the condenser tube shall be warmed when necessary to prevent the deposition of any sublimate. The percentages of fractions should be reported both by weight and by volume.

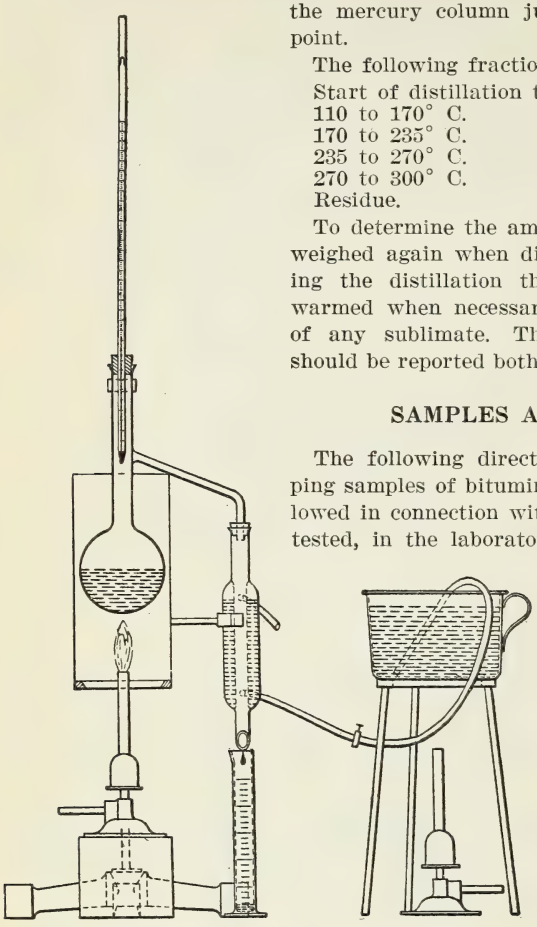

FIG. 8.—Distillation apparatus.

SAMPLES AND SAMPLING.

The following directions for selecting and shipping samples of bituminous materials should be followed in connection with materials which are to be tested, in the laboratory, for conformity with the foregoing specifications.

GENERAL DIRECTIONS.

(1) Samples should be taken so as to represent as nearly as possible an average of the bulk of material sampled and should also be selected with a view to ascertaining the maximum variation in characteristics which the material may possess. (2) Care should be taken that the samples are not contaminated with dirt or any other extraneous matter and that the sample containers are perfectly clean and dry before filling. (3) Immediately after filling, the sample containers should be tightly closed and properly marked for identification, the identification being placed on the container itself and not on the lid unless both container and lid are marked. (4) Samples should be packed for shipment in such manner that leakage of contents or contamination by excelsior, paper, or other packing material during transit is entirely prevented, as well as obliteration or removal of the identification marks. (5) Notification of shipment of samples, with statement of identification marks and such other descriptive information as may be necessary, should be promptly forwarded to the laboratory.

FREQUENCY OF SAMPLING.

(1) Each consignment of bituminous material should be sampled. (2) Additional samples should be taken whenever the material changes materially in

appearance or general character. (3) When the material is fluxed or maintained in heating kettles at an elevated temperature for periods of over 12 hours at least one sample should be taken and tested for consistency each day during its use.

INFORMATION ACCOMPANYING SAMPLES.

Whenever possible the following information should be furnished the laboratory in connection with each sample submitted.

1. Identification mark.
2. Name of material.
3. Name and address of producer.
4. To be examined for conformity with —— specification.
5. Name and location of road where material is to be used.
6. Proposed method of use or type of construction in which material is to be used.
7. Date sample taken.
8. Place sample taken.
9. Sample taken from (storage tank, tank car, barrel, drum, distributor or heating kettle).
10. Material shipped in (car No. —, Tank car No. —, barrels, drums, automobile distributor, or tank wagon).
11. Date shipped.
12. Date received at destination.
13. Date used or to be used if satisfactory.

TIME AND PLACE OF SAMPLING.

(1) Whenever practicable bituminous materials should be sampled at the point of manufacture, and at such time as to allow the tests, controlling acceptance or rejection, to be made in advance of shipment. (2) When impracticable to take samples at point of manufacture they should be taken from the shipment immediately upon delivery.

SIZE OF SAMPLES.

Samples of not less than one quart should be taken except that 3-ounce samples of asphalt cement or refined tar may be taken when the only test to be made is the penetration test or float test, as covered by direction No. 3 under "Frequency of Sampling."

CONTAINERS.

(1) Containers for liquid bituminous materials should be 1-quart, small-mouth cans with screw cap or cork stopper. (2) Containers for semisolid and solid materials should preferably be 1-quart friction-top cans. (3) Samples of asphalt cement or refined tar which are to be subjected only to the penetration test or float test may be sent in 3-ounce round tin boxes with tight-fitting cover.

IDENTIFICATION OF SAMPLES.

(1) The container for each sample should carry a suitable mark which will clearly identify it in connection with additional information which should be furnished the laboratory. (2) For marking tin cans, a 10 per cent solution of silver nitrate may be used, provided the marking is allowed to thoroughly dry before the sample is packed. (3) Gummed labels may be used if the outside of the can is first scraped so as to present a rough surface upon which the label may be securely attached.

DRIP SAMPLES.

When loading tank cars, barrels, or drums from a storage tank, cooler, or still, drip samples may be taken. The material should be allowed to flow

through the discharge pipe for a short time before the sample is taken and the drip valve should be so regulated that the operation of collecting the sample continues through the entire period of loading the containers.

SAMPLING FROM STORAGE TANKS AND TANK CARS.

(1) When the material is in a fluid condition three samples should be taken from each tank or tank car, one from the top, one from the bottom, and one from the center of the tank. The bottom sample may be taken from the discharge pipe through which a sufficient amount of the material is first allowed to flow so as to clean it properly. If there is no outlet at the middle of the tank a thief sample may be taken by lowering a closed bottle or can to the center of the tank and then removing the stopper or cover by means of a stout cord or wire to which it is attached. (2) Tank cars containing cold semisolid or solid bituminous material may be sampled through the dome by the use of a clean hot shovel.

SAMPLING FROM BARRELS AND DRUMS.

(1) Separate samples should be taken from not less than 3 per cent of the containers. (2) When the material is semisolid or solid samples should be taken at least 3 inches below the surface. A hatchet may be used if the material is hard and a broad stiff putty knife if the material is soft.

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